**ANNOTATION**

**dissertation of Amrenova Dana Temirbolatovna "Improving the reliability of emergency automation of transformers", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D071800 - "Electric Power Engineering"**

**Relevance**

An analysis of world publications available in the open access has shown that all newly developed and manufactured devices for automatic transfer switch (ATS)and automatic reclosure(AR) are focused on improving technical perfection. At the same time, little attention is paid to the issues of ensuring their hardware reliability, although according to [5], automatic transfer switch devices (ATS) occupy the first place in terms of failure among all relay protection and automation devices, and automatic reclosure devices (AR) are the seventh. Along with the failure of the ATS and AR devices, the fail of the intakes of reserve supplementbreakeris possible (for example, bus section breaker or feeder circuit-breaker), however, new methods that increase the hardware reliability of ATSand AR are not offered. Therefore, their development is relevant. In this paper, the main attention is paid to improving the reliability of automatic emergency control (AEC) of transformers, since they always take part in the power supply of consumers.

**The object of the study** is automatic emergency control of power supply systems.

**The subject of the study** is the ATS and AR devices of transformers.

**The connection of the dissertation topic with general scientific (state) programs.** The work was carried out in accordance with the priority direction of the development of science "Energy and mechanical engineering" and the scientific directions of the B5 the international organization CIGREsubcommittee "Relay protection and Automation".

**The purpose of the work** is to increase the reliability of automatic emergency control of transformers.

**To achieve the goal, the following tasks were set and solved:**

1. Analyze publications on ATS and AR thematic for reliability subject.

2. To develop ways of improvement the ATS transformers reliability.

3. To develop methods of AR of transformers with fuses and lines with breakers.

4. Create models of devices that implement these methods.

5. To evaluate the economic efficiency of the proposed methods for improving reliability.

**The validity and reliability of scientific statements, conclusions and recommendations are confirmed by:** competent use of the fundamental provisions of the theoretical foundations of electrical engineering, relay protection and emergency automation, reliability theory, logic algebra and theory of relay devices, as well as approbation of reports at international conferences, and obtaining 5 author's certificates of Kazakhstan and Russia.

**Scientific novelty of the work:**

1.A method of automatic transfer load of the transformer is proposed (patented), which, unlike the existing ones, consists in adding an ATS device and a bus section breaker into the hot reserve. The algorithm of devicefunctioning,which is implementing this method, and its model are developed.

2.Two methods of transformersATS with fuses have been developed (patented), which make their replacements automatic with the help of isolators and fault throwing switch in case of burnout. Devices implementing these methods are proposed.

3. Developed (patented) a method and device for transmitting electricity, in which an additional hot reserve is installed in parallel with the working feeder breaker, which is automatically turned on when the working unit fails to switch on.

**New scientific results of the work**

1. A method of transformers ATS that ensures the transfer of consumers who have lost power to another source in case of both ATS device and sectional bus connector failure.

2.For the first time, two methods of transformers ATS with fuses and functioning algorithms of devices implementingthem have been developed.

3. A method and device of lines ATS have been developed to reduce the undersupply of energy by increasing the reliability of their switching-on.

**Practical significance of scientific results**

1. The proposed method of transformers ATS makescomposition of the ATS devices circuits with increased reliability possible.

2. The developed methods of transformers ATS with fuses from the side of their higher voltage make the automatic replacement of the blown fuses with spare ones possible.

3. The writing down of algorithms for the functioning of and transformer ATS and AR devices in the form of algebra-logic functions allows them to be performed on elements of any nature.

**Practical value of the work:**

1. The proposed new method of transformers ATS allows to reduce the damage from the unreliability of the ATS scheme for the auxiliary supplies of block-type power stations by almost 2 times.

2. Methods of transformersATS with fuses for the first time provide their automatic replacement. This makes costs reduction by 16-37 % in designing the circuits of transformers ATS of a 110 kV voltage with 25-63 MVA, respectively, possible.

3. The developed method and device of linesATS with a220-500 kVvoltage can bring an economic effect in designing ATS when energy is transferringto consumers in the generator-transformer-line schemes with blocks of 200 MW, 500 MW and 800 MW by 23, 44 and 58 %.

**The following are presented for defence:**

- a new method of transformers ATS and a device that implements it;

- methods and devices of transformers ATS with fuses.

- improved line ATS method;

- results of calculations of the economic efficiency of the proposed methods.

**Approbation of the work.** The main provisions of the dissertation were presented at the International Scientific Conference of Young Scientists, undergraduates, students and schoolchildren "XX Satpayev Readings" (Pavlodar, 2020), XXXVII International Scientific and Practical Conference "Technical Sciences: problems and solutions" (Moscow, 2020). The work was reported in full at an expanded meeting of the Department of Electric Power Engineering at the Toraigyrov University

**Publications.** The research results are reflected in 7 scientific papers, including: 2 patents of the Republic of Kazakhstan and 3 patents of the Russian Federation, 2 publications in the materials of international conferences, 1 of which is foreign. In co-authored publications, the personal contribution of the author is at least 60%.

**The structure and scope of the dissertation.** The dissertation consists of an introduction, three sections and a conclusion. The work is presented on 72 pages of computer text, includes 17 tables, 12 figures. The list of sources used includes 85 titles.

**In the first chapter**, "Devices for automatic reclosure and automatic transfer switch in power supply systems", the well-known ATS and AR devices and their disadvantages, as well as the reliability of automatic emergency control devices, are considered. It is noted that:

1. All newly developed ATS and AR devices are focused on improving their technical perfection. At the same time, they are among the top ten relay protection and automation devices with the worst response reliability indicators. There are no publications related to improving the hardware reliability of ATS and AR devices.

2. Fuses are often used to protect single transformers with a voltage of 6 (10) kV, which provide the most primitive and inexpensive protection of a transformer substation. However, it takes a long time to replace the blown fuses, this operation has not yet been automated by anyone.

3. Currently, more and more attention is being paid to the reliability of the operation of relay protection and automation devices (RPAD). The reliability of operation depends on the hardware, which is conditioned to the degree ofthe component elements reliability. A method of increasing reliability, such as structural redundancy, increases hardware reliability. To evaluate the economic efficiency of the latest mentioned, it is advisable to use a tabular-logical method for calculating the reliability of power supply schemes.

**In the second chapter** "Improving the reliability of automatic transfer switch devices for transformers", the method of ATS for transformers is proposed. In accordance with the method, a verbal description of the condition (algorithm) for triggering the ATS device is formulated. The algorithm of functioning is written in the symbols of the algebra of logic.

According to this algorithm, a new device of transformersATS is proposed. Its implementation and the scheme of the device are considered in detail.

The results of calculations (according to the tabular-logical method) are presented, proving the practicabilityof using this method of ATS in the schemes of auxiliary supplies of electric stations and "Bridge". It is shown that: a) the developed method of ATS of transformers, in comparison to the known ones, allows, in case of failure to switch on the working bus section breaker or failure to activate the ATS device, to ensure the connection of consumers to a backup power source; b) the algorithm of functioning of the device built according to this method through the use of algebra-logic can be implemented on elements of any nature; c) the developed method makes reduction of damage during reconstruction and costs during the design of the ATS scheme for the TPP auxiliary supply with a capacity of 500 and 800 MW units, by 14, 57 and 46, 69 %, respectively, and in the "Bridge" scheme with 40 MVA transformers, without the presence of permanent operational personnel, by 79 and 81 % possible.

**In the third chapter**, "Development of methods for automatic reclosure of transformers with fuses", two methods of transformersARwith fuses are considered. The first method of transformersARconsists in automatic replacement of blown fuses with spare ones with the help of isolators, the second – with the help of fault throwing switches. For both methods the triggering conditions are formulated in the form of a verbal description and in Boolean algebra symbols. Algorithms for the functioning of devices that implement these methods are presented.

The method of linesARand the device implementing it is presented. This method in comparison to the known one provides the transmission of electricity in the event of a failure to turn on the working circuit breaker or the AR device, due to the spare one installed in parallel with the working one, which is in hot reserve.

Calculations of the technical and economic efficiency of the use of AR methods of transformers and lines are given. According to the results of calculations (using the tabular-logical method), it can be argued that in the AR schemes of transformers with fuses and lines proposed by us, it is not possible to achieve an economic effect during the reconstruction of the traditional scheme. When designing the methods of AR of transformers with fuses and lines make it possible to reduce the costs in the circuits: 1) TS 110/10 kV with a transformer capacity of 25, 32, 40 and 63 MVA, by 16, 23, 28 and 37%, respectively; 2) GTL with units with a capacity of 200, 500 and 800 MW, by 23, 44, 58 %, respectively.

**The results of the work are as follows:**

1 A method is proposed for automatic transfer switch (ATS) of transformers, which provides switching of consumers who have lost power to a backup source when the ATS devices fail to operate and the bus section breaker fails to turn on. This is achieved by connecting an additional ATS device in parallel with the traditional one and entering an additional bus section switch into the hot reserve. The calculation using the tabular-logical method showed that this method makes it possible to reduce design costs and damage during reconstruction in the schemes of auxiliary supply of power plants with a capacity of 500 (800) MW units by 57 (69) % and 14 (46) %, respectively, and in the "Bridge" scheme (without the presence of operational personnel) by 81 and 79 %.

2. A method and a device for automatic reclosure (AR) of lines are proposed. The economic effect of their use in the design of generator-transformer-line units with a capacity of 200, 500 and 800 MW reaches 23, 44, 58 %, respectively.

3. For the first time, methods and devices of AR transformers with fuses have been developed that allow them to be replaced automatically in case of burnout. The economic effect in the design of 110/10 kV AR transformers with a capacity of 25-63 MVA is 12-67%, respectively.

4. The algorithm of functioning of all the developed devices through to the use of algebra-logic in their construction allows implementing these devices on logical elements of any nature.

5. It is recommended to implement: 1) the method of ATS of transformers in the scheme of agricultural power plants with a capacity of blocks of 500 MW or more and in the "Bridge" scheme with transformers of 40 MVA; 2) AR of transformers of 40 ÷ 63 MVA with fuses at a voltage of 110/10 kV and AR of lines in the generator-transformer-line schemes with blocks of 500 and 800 MW.